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DAY-DEGREE ESTIMATES FOR THE IMMATURE STAGES OF THE TASMANIAN EUCALYPTUS LEAF BEETLE *CHRYSOPHTHARTA BIMACULATA* (OLIVIER) (COLEOPTERA: CHRYSOMELIDAE)

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Abstract

Using published and original constant-temperature data, the lower temperature threshold for development (= the developmental zero, DZ) and the number of day-degrees (DDs) required for development (= the thermal constant, K) are estimated for each of the immature stages of *Chrysophtharta bimaculata* (Olivier). These are: egg, DZ = 0.55°C, K = 112 DDs; 1st instar larva, DZ = 5.50°C, K = 49 DDs; 2nd instar larva, DZ = 4.71°C, K = 41 DDs; 3rd instar larva, DZ = 3.77°C, K = 46 DDs; 4th instar larva, DZ = 3.78°C, K = 64 DDs; pre-pupa and pupa combined, DZ = 5.41°C, K = 184 DDs. Using a simple day-degree model, examples are given on how this information may be used in the field.

Introduction

Chrysophtharta bimaculata (Olivier), the Tasmanian eucalyptus leaf beetle, is the most serious insect pest of forestry in Tasmania (Elliott *et al.* 1992). Adults and larvae defoliate commercially important *Eucalyptus* species, such as *E. nitens* (Deane & Maiden) and *E. regnans* (F. Mueller). Adults lay their eggs on host foliage, where the larvae develop through four instars, before falling from the tree to pupate in the soil (Greaves 1966, de Little 1983). Constant temperature development times for the immature stages of *C. bimaculata* are given by Greaves (1966) and de Little *et al.* (1990); however these data have not been used to develop day-degree models for estimating field development rates. Additionally, constant temperature data for pupal development times are given only by Greaves (1966) and are of insufficient detail to allow modeling.

As biological insecticides such as *Bacillus thuringiensis* and *Metarhizium* spp. are developed for use against *C. bimaculata* (Greener and Candy 1994; Anonymous 1996), there is an increased requirement to be able to estimate rates of development for immature *C. bimaculata* in the field. This need arises because biological insecticides tend to be much more specific against certain insect life-stages than are conventional insecticides. Thus, a field operator may need to know if eggs have hatched, or if larvae have developed into later instars. Using only daily maximum and minimum temperatures, day-degree models are the simplest means of estimating field development rates and establishing the likelihood of these events.

Materials and methods

Constant temperature development times for eggs and larvae

Times of development, in days, for eggs and all larval instars at different constant temperatures (viz. 8, 15, 20, 24 and 27°C) were obtained from de Little *et al.* (1990).

Constant temperature development times for pupae

Ninety-six prepupal larvae were gathered from the bottom of a rearing cage that held a large branch of *E. regnans* on which larvae were feeding. Prepupal larvae are easily distinguished from other 4th instar larvae by their general immobility and a slight colour change that occurs after feeding ceases; larvae become paler as the gut voids. Prepupal larvae were placed into individual containers and 16 were then randomly assigned to each of six constant temperatures (viz. 5, 10, 15, 18, 20 and 29°C). Larvae were checked daily and dates of pupation and adult emergence were recorded.

Estimation of development parameters

Estimation of development parameters follow the approach described in Gullan and Cranston (1994, p 170). The rate of development at a given constant temperature, T_1, was determined as the reciprocal of the time of development in days (Dev_1) at T_1 (i.e. rate at $T_1 = 1/ Dev_1$). A linear regression was then carried out for temperature versus developmental rate. The developmental zero (DZ), the lower temperature at which development ceases, was then estimated by solving the regression equation for rate = 0. The number of day degrees required to complete development (= the thermal constant, K) for a given temperature T_1, was determined by solving the equation: $K = Dev_1 * (T_1 - DZ)$. For each life-stage, the K value given in the results is the average of the K values determined for each constant temperature.

Results

Regression equations of temperature versus development rate, developmental zeros and thermal constants for each immature stage of *C. bimaculata* are given in Fig. 1. Estimated developmental zeros range from 0.55°C for eggs to 5.50°C for 1st instar larvae. Thermal constants for the larval stages range from 41 to 64 DDs, but are markedly longer for eggs (K = 112 DDs) and pupae (K = 184 DDs).

Discussion

The number of day degrees experienced by an insect in the field on any given day may be estimated as: DDs = [(daily maximum temperature + daily minimum temperature)/2] - DZ.

A 1st instar *C. bimaculata* larva with a thermal constant of 49 DDs, for example, when exposed to three consecutive days with maximum and minimum temperatures respectively of 32/16, 30/14 and 24/10°C, will experience a total of 46.5 DDs and will develop nearly to the second instar. These values should not be seen as absolute figures, as behaviour such as basking and sheltering may vary the temperature which an insect experiences. Additionally, the estimates of DZs are exactly that, estimates, and may be several degrees out from the true value. Further research is warranted to more accurately determine K and DZ values and to determine how larval behaviour may modify the temperature experienced by the insect.

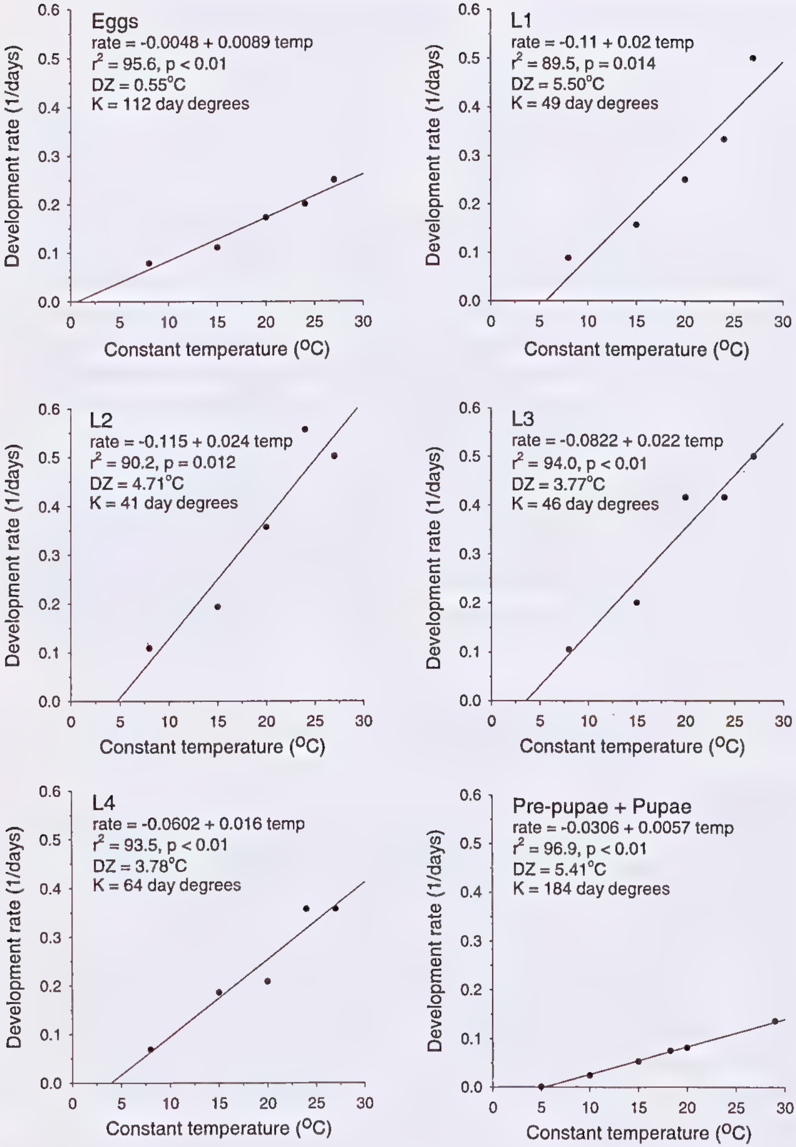

Fig. 1. Scatter plots of constant temperature versus development rate for the egg, four larval (L1-L4) and combined pre-pupal and pupal stages of *Chrysophtharta bimaculata*. The linear regression is fitted to each plot and the regression equation and corrsponding r^2 value given. DZ is the developmental zero and K is the estimated thermal constant.

Despite these limitations, the values presented here may be used by researchers and field operators as an aid to estimating how field populations of *C. bimaculata* may be developing, without the need to visit sites. Also, long-term local temperature averages may be used to predict the period of time an operator has in which to implement a control practice. For example, if *Bacillus thuringiensis* formulations have to be applied against eggs or 1st instar larvae to be effective, then the operator has at most 151 DDs from when eggs are first laid in which to spray. In January, monthly, long term maximum and minimum temperatures for Burnie (41°04_S, 145°57_E) and Geeveston (43°09_S, 146°55_E) are 21.3/12.8°C and 21.7/9.3°C respectively (Australian Bureau of Meteorology, WWW page). This equates to an maximum operational window of approximately 11 days and 12.5 days respectively for these two districts. However, if eggs are already beginning to hatch when first observed, the window of opportunity for spraying is much reduced, to approximately 4-5 days.

When estimating pupal development times in the field, it should be remembered that soil temperatures are significantly buffered in comparison to air temperatures. For 60 daily readings taken in the Florentine Valley in December 1993 and January 1994 (A. LaSala, unpublished data), soil temperatures at 10 cm depth, below a tree canopy, were on average 1.7°C and 5.1°C greater than the respective daily, dry-bulb maximum and minimum air temperatures.

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